ing to the Denver grading scale were; grades 1=24%, 2=35%, 3=4%, 4=35%, and 5=2%. Distribution across segments included; V1=18%, V2=67%, V3=31%, and V4=6%. Only one posterior circulation stroke was attributable to VAI. Overall mortality was 8% being associated with other injuries. Treatment rendered was antiplatelet therapy (50%), observation (29%), warfarin (17%) or stent (4%). Follow-up was obtained with 13% (n = 6) of survivors. CT angiogram or MRA demonstrated injury stability in 4 patients and resolution in 2 patients. Accuracy of the administrative trauma database was 53% compared with 96% for the resident-run working database.

**Conclusions:** Neurologic sequelae attributable to VAI was rare. Grade of VAI or vertebral artery segment did not correlate with morbidity. Posterior circulation stroke was low. Patient morbidity and mortality was attributable to severe associated injuries. Of those seen at follow-up, injury resolution or stability was documented by CT angiogram. A conservative approach with either observation or anti-thrombotic therapy is suggested. Our search strategy urges awareness of the limitations of administrative databases for retrospective vascular study.

### Carotid Endarterectomy is More Cost-Effective Than Carotid Artery Stenting

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**Background:** In a clinical environment where there may be emerging clinical equipoise between two therapies, the cost of delivering that intervention becomes increasingly important. Carotid Endarterectomy (CEA) and carotid artery stenting (CAS) have both demonstrated a reduction in long-term stroke risk after successful intervention. While the CREST trial demonstrated no significant differences between CAS and CEA regarding the peri-operative risk when the primary endpoint of CVA, death or MI was examined, a meta-analysis of European randomized prospective trials in symptomatic patients strongly favored CEA as the safer procedure. In the United States, the percentage of gross domestic product (GDP) devoted to medical care continues to rise at a rate that is unsustainable. Going forward, more efficient use of health care dollars will be essential. Preferential use of the most cost-effective therapy for a given clinical problem should be part of the solution. In an effort to further compare treatment of carotid disease, we analyzed hospital cost and clinical outcome data of patients undergoing CEA and CAS.

**Methods:** A retrospective analysis of hospital cost and 30-day outcomes was performed on patients undergoing CEA and CAS between 1/1/2008 and 9/30/2010 at a single tertiary referral institution. The hospital patient database was queried using CPT codes to search for those patients who had either undergone CEA (CPT 35301) or CAS with embolic protection (CPT 37215) during the specified period.

**Clinical Definitions:** Patients were considered to be symptomatic from their carotid disease if they had experienced ipsilateral amarousis fugax, transient ischemic attack (TIA) or stroke. Urgent interventions were defined as those patients admitted with an acute cerebral or ocular ischemic episode who were found to have significant ipsilateral carotid disease and underwent intervention during the index hospitalization. The 30-day clinical major adverse event was defined as a composite of any stroke, death and MI.

**Cost Calculation:** The institution's financial department performed an analysis of hospital cost (not charges) on the main patient cohorts and subgroups detailed above. Professional fees were not included in this analysis. The cost of the procedure was based on a cost accounting method using the relative value unit (RVU) system. Each procedure or item charged to a case was assigned an RVU. Costs were then calculated based on the relative RVU valuation. The cost items were assigned to the following cost centers: labor expense, supply expense, facility/equipment expense, and miscellaneous. Once the total expense for the index hospitalization was calculated, it was normalized to 2010 costs based on the medical consumer price index. Statistical analysis was performed with Wilcox's analysis, X2, and Fisher's exact test.

**Results:** Three hundred and fifteen patients underwent either CEA (n = 174) or CAS (n = 141) between 1/1/2008 and 9/30/2010. Nine patients were excluded from the primary cohort (all receiving CAS) because they had other associated procedures during the index hospitalization which would have biased the economic analysis. Thus, the final examined cohort was 306 patients who underwent CEA (n = 174) or CAS (n = 132).

**Demographics:** There was a strong trend towards more symptomatic patients in the CEA cohort (44%, n = 78) compared to the CAS group (34% n = 45) which did not attain statistical significance ($P$ = .058). The frequency of urgent intervention was similar between groups [CEA 12.6% (n = 22) vs CAS 10.0% (n = 14); $P$ = .72). The mean age in the CEA and CAS groups was 70.1 ± 9.8 yrs. and 72.0 ± 9.7 yrs, respectively ($P$ = .36). There was a trend towards a higher prevalence of medical co-morbidities in the CAS cohort compared to the CEA cohort (94.5% vs 88.9%, respectively; $P$ = .07), with a higher prevalence of CAD (61% vs 37%, $P$ = ,0001) and CHF (18.2 vs 5.2%, $P$ = .0003) in the CAS cohort.

**Hospital Cost:** The hospital cost for CAS ($9426 ± 5776) was 40% greater than that of CEA ($ 6734 ± 3935, $P$< .0001). This cost differential was driven by a mean difference of $3667 in higher direct supply costs in the CAS group ($5634 ± 3384) compared to the CEA group ($1967 ± 1967, $P$ = .0001). There were no significant differences between CEA and CAS in regards to labor or facility costs (Fig 1). Subgroup analysis was performed comparing the cost of CEA and CAS for asymptomatic, symptomatic, elective, and urgent procedures (Fig 2). In all sub-group cohort comparisons, there was a consistent increase in cost for CAS compared to CEA. All of these differences were statistically significant ($P$< .001) except the urgent subgroup ($P$= .07). Cost of CAS and CEA was also examined in relation to patient enrollment in a trial or registry. Patients undergoing CAS who were enrolled in a trial or registry (53.8%, n = 71) incurred significantly less cost ($7779 ± 3525) compared to those who were not (n = 61, $11,279 ± 7114, $P$ = .0004). There were no significant differences in cost for patients undergoing CEA regarding trial status.

**Clinical Outcome:** The 30-day major adverse event rate (stroke, death, MI) was 2.3% in the CEA group and 3.8% in the CAS group ($P$ = .5).

**Length of Stay:** Overall LOS was 2.1 days in both CEA and CAS groups ($P$ = .9). LOS in patients with symptomatic disease (2.9-3.6 days) or who had urgent intervention (7.3-7.5 days) was much greater than patients undergoing intervention electively or for asymptomatic disease (1.3-1.4 days). The LOS between CEA and CAS was similar in all these subgroups.

**Conclusions:** The hospital cost of CAS was demonstrated to be 40% greater than CEA. The cost differential in the present study was driven largely by the significant differential in direct supply costs in the CAS group of $3667. Current hospital costs for a carotid stent and embolic protection device is approximately $3750 - 4100 compared to $90-100 for a synthetic carotid patch used with endarterectomy. Clearly, the cost differential of these two therapies was due to the relatively high cost of the interventional products required for CAS. There was no net significant offsetting savings in facility or labors costs for the CAS patients as the length of stay was similar between the two treatment groups. This is the first carotid economic study to examine multiple treatment subgroups. Patients with urgent intervention incurred costs much greater in both groups than those who where treated electively. This cost differential was driven by the much greater LOS for urgent cases (7.3-7.5 days) compared with elective cases (1.3-1.4 days). Additional cost for diagnostic imaging in these cases also likely contributed. Patients being treated for symptomatic disease likewise had greater costs than those treated for asymptomatic disease. Increased LOS in the symptomatic groups (2.9-3.6 days) verses the asymptomatic group (1.3-1.4 days) certainly played a role. The relative cost trends between CAS and CEA seen in the primary cohorts were not altered in any subgroup. CAS was consistently more costly in each subgroup. A novel finding of this study was that CAS patients enrolled in a trial or registry had costs that were significantly less than those who were treated with CAS outside of a trial. These data refute the notion that the differential in cost between CEA and CAS is due, in part, to additional costs associated with protocol-mandated imaging and testing for patients enrolled in a trial or registry. The present study represents a "real world" cost analysis of CEA and CAS performed at a single, tertiary referral center with significant expertise and experience in both therapies. As such, it may provide a more realistic view of costs compared to data generated from clinical trials. While a small number of patients were part of randomized prospective trials (CREST, ACT-1), most treatment decisions were made by the intervening physician. Selection bias is a clear concern and could confound attempts to compare the treatment groups. In an attempt to decrease this possibility, we excluded patients who had other major procedures during the index hospitalization, or who were not admitted primarily because of TIA, stroke or carotid disease. Did the treatment groups have disparate demographics or clinical presentation? Patients undergoing CEA were more likely to have symptomatic disease when compared to those undergoing CAS. As symptomatic status is a very strong risk factor for peri-procedural stroke, this difference would suggest that the CEA group was at higher risk of a poor outcome, potentially biasing the results against CEA. Conversely, in the CAS group there was a higher prevalence of CAD and CHF, suggesting that group had a higher potential cardiac morbidity, potentially biasing the results against CAS. Patient age and other medical co-morbidities were similar between treatment groups. In conclusion, CAS was associated with a 40% cost premium when compared to CEA, and did not provide any improvement in clinical outcome or LOS. All subgroups had similar cost trends. Given the lack of clinical improvement and its cost premium, CAS cannot be considered routinely cost-effective for the treatment of carotid artery disease.

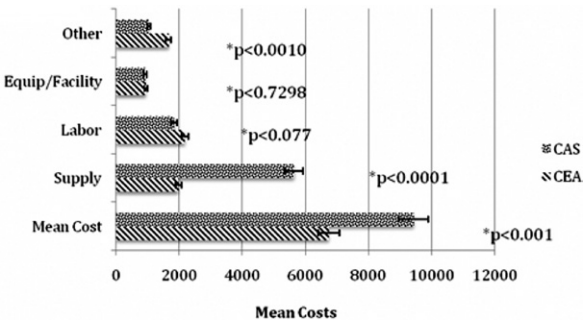


**Fig 1.**

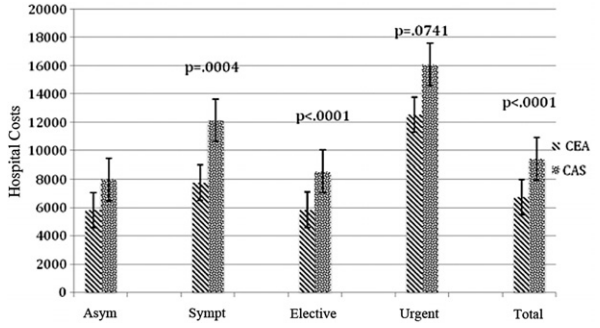


**Fig 2.**

**Cerebral Embolization in Asymptomatic vs Symptomatic Patients After Carotid Stenting**

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**Background:** Previous studies have investigated the development of new ischemic brain lesions on diffusion-weighted MRI (DW-MRI) after carotid artery stenting (CAS) for symptomatic stenosis. The rate of ischemic brain injury after CAS for asymptomatic stenosis has not been established, but is presumed to be less likely. This study assessed the occurrence of cerebral embolization after CAS for asymptomatic vs symptomatic carotid stenosis.

**Methods:** During an 18-month period, 40 patients undergoing CAS under filter embolic protection were prospectively evaluated. Transcranial Doppler (TCD) during CAS and pre- and 24-hour postprocedural DW-MRI were used to assess cerebral embolization. Univariate and nonparametric analyses were used to compare differences in cerebral embolization after CAS in asymptomatic and symptomatic patients.

**Results:** CAS was performed for 23 (58%) asymptomatic and 17 (42%) symptomatic carotid stenoses. The median microembolic counts detected by TCD were 285 (interquartile range [IQR], 182-376) for asymptomatic and 313 (IQR, 170-426) for symptomatic carotid stenosis (P=.6). New acute cerebral emboli detected with DW-MRI occurred in 50% of asymptomatic and 50% of symptomatic patients undergoing CAS ($P = .9$). The ipsilateral and total median number of DW-MRI lesions between groups were not statistically significantly different, i.e. 1 (IQR, 0-2.5) and 1.5 (IQR, 0-3) vs 0.5 (IQR, 0-2) and 0.5 (IQR, 0-3) for asymptomatic vs symptomatic carotid stenosis, respectively ($P > .5$). One asymptomatic patient sustained a minor stroke after CAS, whereas no new neurologic events occurred in symptomatic patients; the 30-day stroke-death rate was 2.5% in this series.

**Conclusions:** Cerebral embolization, as detected by TCD and DW-MRI, occurs with similar frequency after CAS for asymptomatic and symptomatic carotid stenosis. This observational study questions the safety of CAS under embolic protection for asymptomatic carotid stenosis as new ischemic brain injury occurs in approximately half of these procedures.

**Contralateral Occlusion is not a Clinically Important Reason for Choosing Carotid Artery Stenting for Patients with Significant Carotid Artery Stenosis**

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**Introduction:** Patients with internal carotid artery occlusion contralateral to a diseased carotid artery are at an increased risk of stroke. It is our practice to offer carotid intervention to symptomatic patients and patients with severe ipsilateral carotid stenosis and contralateral occlusion. Both carotid endarterectomy (CEA) and carotid artery stenting (CAS) are acceptable modes of therapy. Contralateral carotid occlusion has been suggested as an indication for CAS because of the theoretical advantages of reduced ischemic procedural time and the lack of need for a vascular shunt or the assistance of general anesthesia. However, CEA can also be done safely in this population and has been associated with a decreased procedural stroke rate. Thus, it is not clear if contralateral occlusion by itself is an appropriate indication to prefer CAS over CEA. Here we compare our institution's perioperative and one-year follow up experience with both CEA and CAS for patients with severe carotid artery stenosis and contralateral internal carotid artery occlusion.

**Methods:** This is a retrospective review of our institution's collective consecutive patient experience with CAS and CEA from 2/2007-7/2011. Choice of therapy was determined by operator preference among vascular surgery, cardiology, and interventional radiology, and the data collection was performed using our computerized patient record after approval from the Institutional Review Board. Patients were considered for review when treated for carotid artery stenosis with contralateral carotid occlusion.

**Results:** Out of a total of 713 patients treated for carotid artery stenosis during this time period, 60 had contralateral occlusion. 40 of these patients were treated with CAS, and 20 with CEA. The most common indication for CAS were prior neck surgery (18), contralateral carotid occlusion alone (9), and prior neck radiation (7). The average age was 69.8 (+/− 8.1) for CEA and 67.2 (+/−8.7) for CAS. There was a male bias in both groups (CEA 13/20; CAS 29/40; P=.56), and both groups had similar amount of symptomatic patients (CEA 10/20, CAS 19/40). Two patients died within 30 days in the CAS group (5%) and no deaths occurred within 30 days in the CEA group. No perioperative strokes or myocardial infarction occurred in either group. One transient ischemic attack occurred after CAS. At mean follow up of 28+/− 16 months (CEA) and 28+/−15 months (CAS) (range 1.5-48.5 months), 7 deaths occurred in the CAS group and two in the CEA group (17.5% vs 10%, $P = .7$). There were no reoperations in the CEA group and one intervention in the CAS group for in-stent stenosis.

**Conclusion:** Although CEA and CAS can both be performed with good perioperative and midterm results, we find no reason to prefer CEA over CAS in patients whose only reason for consideration of CAS is contralateral occlusion.

**Early Versus Delayed Carotid Endarterectomy for Symptomatic Carotid Stenosis: A Single-Institution Experience**

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**Introduction:** Delayed carotid endarterectomy (CEA) after a recent stroke or transient ischemic attack (TIA) is associated with risks of recurrent neurologic symptoms. In an effort to preserve cerebral function, urgent early CEA has been recommended in some instances.

**Methods:** Retrospective chart review from a single university hospital tertiary care center between November 1998 and February 2011 revealed 309 patients who underwent CEA following stroke or TIA. Of these 309 patients, 87 received their CEA within 30 days of symptom onset and 222 received their CEA after 30 days from symptom onset. The early CEA cohort was further stratified according to the timing of surgery: Group A (33 patients), within 7 days; Group B (21), between 8 and 14 days; Group C (17), between 15 and 21 days; and Group D (15), between 22 and 30 days. Demographic data as well as 30-day (mortality, stroke, TIA, and myocardial infarction) and long-term (all-cause mortality and stroke) rates were analyzed for each Group. These were also analyzed for the entire early CEA cohort and compared against the delayed CEA cohort.

**Results:** Demographics and co-morbid conditions were similar between groups. For 30-day outcomes, there were no deaths (0%), two strokes (2.4%), two TIAs (2.4%), and two myocardial infarctions (2.4%) in the early CEA cohort; in the delayed CEA cohort, there were 4 (1.8%), 4 (1.8%), 3 (1.4%), and 3 (1.4%) patients with these outcomes, respectively ($P > 0.05$ for all comparisons). Over the long-term, the early group had one ipsilateral stroke at 17 months and the delayed group had two ipsilateral strokes at 3 and 12 months. For long-term outcomes, there were 21 deaths in the early CEA cohort (24.4%) and 67 deaths in the delayed CEA cohort (30.2%, $P > .05$). Mean follow-up times were 4.5 years in the early CEA cohort and 5.8 years in the delayed CEA cohort.

**Conclusions:** There were no differences in 30-day and long-term adverse outcome rates between the early and delayed CEA cohorts. Early CEA is preferred in carefully selected patients following a TIA or non-disabling stroke over delayed CEA.

**Robotic Thoracoscopic First Rib Resection and Scalenectomy for Treatment of Pagett-Schroetter Syndrome**

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**Objectives:** First rib resection is a key component of the treatment for axillo-subclavian venous thrombosis due to thoracic outlet compression (Paget-Schroetter syndrome). Previously described techniques, transaxillary